The Athena SDM Rover: a Testbed for Mars Rover Mobility

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NASA will send a series of missions to Mars during the next decade. The Athena rover was designed for a surface exploration and Sample Return mission, but as of August 2000 has been superceded by a new mission plan; two Mars Exploration Rovers (MERs) will explore the Red Planet in early 2004. Still, many person-years went into the development of a test vehicle, the Athena Software Development Model (SDM) rover. This vehicle now serves as a research platform on which MER Mobility Software is being refined and tested.

The Athena SDM rover is an engineering testbed for Earth-based testing of Mars Rover capabilities on a realistic platform. Its onboard electronics are prototypes of those that might have one day flown to Mars, though its mechanical chassis is copied from JPL's FIDO research rover instead of from the flight mechanical design. It is approximately 100 x 75 x 45 cm^3, with a six-wheel rocker bogie suspension on which four wheels can be steered, weighing approximately 60 kilograms. Its R3000 CPU runs at 12 MHz, a fifteen times improvement over the Sojourner rover. Additional processors handle low level motor control; these six Remote Engineering Units (REUs) remove the burden of busy-waiting during driving or steering operations from the general purpose CPU. The faster CPU, the additional processors, and a large 32 Meg DRAM memory and 64 Meg Flash memory have allowed the implementation of much more intelligent capabilities for surface navigation than were possible on Sojourner.

Multiple sensors allow the rover to reason about its environment before and while driving in it. Reactive sensors include an Inertial Measurement Unit (IMU), contact sensors, motor current thresholding, a Sun sensor camera, and encoder-based wheel odometry. These provide immediate pose estimation, and information about the terrain immediately next to the rover. Predictive sensors include three pairs of engineering stereo cameras, which predict the shape of the terrain ahead the vehicle, thus enabling the rover to plan its own path to avoid any obvious pitfalls. One stereo camera pair is mounted on a mast approximately 140 cm above the ground. JPL Stereo Vision software provides the raw range data used to autonomously understand the local terrain elevations, and a variation of Reid Simmons' Morphin planner processes this range data and evaluates a variety of possible paths, choosing the safest route that lets the rover make progress toward its goal.

A simple and robust software architecture was developed to implement these capabilities. In this architecture a series of ground-generated commands are received and stored on board for processing by a Command Sequencer. As each command terminates, it has the option of setting a status indicator. Subsequent commands must explicitly reset these indicators if they wish to continue, otherwise the system logs the error and executes recovery operations.

In this paper we describe the overall Athena SDM rover system, detail its software architecture, describe the development environment, and provide experimental data demonstrating its ability to meet mission navigation requirements by being able to safely drive 100 meters within three hours.